A STUDY OF

The Teaching of Mechanical Drawing

In the Public Schools, Colleges and Universities of Ohio

By
CARL L. SVENSEN, M. E.
Department of Engineering Drawing
The Ohio State University

Published by the
Department of Education

VERNON M. RIEGEL, Director

COLUMBUS, OHIO
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FOREWORD

By Thomas E. French, M. E., Sc. D.

Head of Department of Engineering Drawing, the Ohio State University

The position of the Ohio State University as a part of the educational system of the State indicates that it should possess an adequate knowledge of the preparation which has been received by the students entering it. The University is interested, without any idea of domination, in the work of the public schools, and it is believed the schools are interested in the judgment and suggestions of the University.

In any subject a knowledge of what is being done by others is always stimulating. It is particularly desirable in subjects whose content and methods of teaching have not yet become more or less standardized by experience and agreement. In a fundamental subject there would seem to be little reason for wide variation in the content of courses. It ought to be possible for pupils to transfer easily from one school to another, or for students to change from one college to another without loss of credit.

The great popular interest in industrial and engineering work has resulted in an increased use of mechanical drawing as a means of description. It is rapidly becoming a part of our language and its influence is shown by its widespread adoption as a fundamental subject of study.

While mechanical drawing has been taught in some schools for many years there probably has been less thought given to its purpose, its content, its methods and its educational value than other subjects have had. The wide variation in the qualifications of students entering the University with entrance credits in drawing, indicating a seeming lack of uniformity in these courses, has interested the writer for a number of years, and, for one thing, resulted in a survey of mechanical drawing in the High schools of Ohio.* This survey aroused the feeling that there should be closer co-operation, and that an attempt should be made to bring about some degree of standardization as to content, method and purpose. The preparation and qualifications of the teachers of this branch of drawing would naturally be included. Interest in the subject, and the idea that, as the High School is midway between the grades and the colleges, the survey might be extended in both directions, with profit to all three, led Professor Svensen of the Department of Engineering Drawing, Ohio State University, to continue the study by making a sur-

*Mechanical Drawing in High Schools, by Thomas E. French and Carl L. Svensen. Published by the Department of Public Instruction, State of Ohio, 1919.

vey of the work in mechanical drawing in the grade schools and in the colleges of Ohio.

The results of his study are here presented, with suggestions and comments which it is hoped may help bring about a closer degree of co-operation and mutual helpfulness between the various educational divisions.

The value of this work has been recognized by the granting of a graduate degree to Professor Svensen by his Alma Mater, Tufts College, which accepted the material as a thesis.

A STUDY OF THE TEACHING OF MECHANICAL DRAWING IN THE STATE OF OHIO

By Carl L. Svensen, B. S., M. E.

SECTION I

General Introduction

The civilization of mankind has progressed through the ages due to the accumulation of knowledge and its dissemination. Fire and water have contributed immeasurably to bodily comfort, but the development of a language, spoken and written has really made civilization possible.

The oldest of all languages, the graphic language, has made possible the industrial or mechanical age in which we now live. It is therefore desirable that a study of the teaching of this language should be made on a statewide basis and that an appreciation of what is being done and what it is possible to accomplish through the development and coordination of courses in drawing should be made known.

Mechanical drawing has come to be recognized as one of the fundamental courses of study in the State of Ohio and is quite generally taught in the grade schools, high schools, colleges and universities of the State.

The Purpose and Plan of this Study

This study is undertaken with the idea of presenting the subject of mechanical drawing in such a manner as to inspire a certain degree of appreciation of its place in the curriculum, to present the subject in its true light as having both practical and cultural value, to present information as to the extent to which mechanical drawing is taught in the schools of the State to assist in correlating the courses as given in grade schools, high schools and colleges, to present information as to character, content and development of courses of study, to present information and ideas which may be of value to teachers of mechanical drawing and which may help to raise the standards of teaching this subject.

It is hoped that this study may tend to a realization of the value of treating mechanical drawing as a continuous and progressive subject from the grades through the university.

It is hoped that this study may lead to a more complete realization of the value of mechanical drawing as a cultural subject with unlimited possibilities in an educational way.

Mechanical Drawing — A Language

Drawing was the first means of recording and communicating man's ideas and will always continue to be a most valuable and definite language.

In the preface to Dean Anthony's "Mechanical Drawing" the fact is emphasized that mechanical drawing is a language. He says that the student "should be taught to regard graphics as a language study, the grammatical construction of which is developed in the Theory of Projection. . . . the subject should be taught as an art of expression rather than one of pictorial representation. Although most people recognize drawing as a medium for conveying thought, few appreciate the importance of teaching it as a language. But such it is in the fullest sense, possessing a well-defined grammatical construction, rich in varied forms of expression, forcible yet simple, and truly universal."

Professor French says in the preface to "Engineering Drawing," "It would seem that a better unity of method might result if there were a better recognition of the conception that drawing is a real language, to be studied and taught in the same way as any other language."

This conception of drawing as a language is by no means modern for the statements of James Nasmith eighty years ago might well seem to be the words of today. A few quotations from Nasmith's autobiography are worthy of reflection. "It is very strange that amid all our vaunted improvements in education, the faculty of comparison by sight, or what may commonly be called the correctness of the eye, has been so little attended to."

"Drawing is the education of the eye, it is more interesting than words. It is the graphic language."

"Mechanical drawing is the alphabet of the engineer, without this the workman is merely a hand,— with it he indicates the possession of a head."

Languages are a means of thought as well as a means of expression. It is possible for an Englishman, a Frenchman, and a German to have the same thought, each in his own language but these thoughts when put into writing will have a different appearance and may mean nothing except to those who know the particular language used. However, if the graphic language is used the meaning will be the same to all, as no variation can be made in the appearance of a graphic statement or description without changing its meaning. Peculiarities of tongue, geographical location, or other influences have no effect upon the graphical language. As a means of exact description it surpasses all other languages, it develops exact thinking, it develops the imaginative powers, it develops the power of accurate observation, and opens the way to the enjoyment and use of the unlimited possibilities of these powers.

Historical Notes

The graphical language has always been an invaluable aid in the progress of mankind toward civilization and in the development of that civilization. It seems very probable that plans of some kind were used

by the ancients, as their works were most always built to a scale based upon a definite unit of measurement. This unit appears to have been derived from some part of the human body and so has varied among different peoples. Tradition informs us that the length of the foot of Hercules was the standard of Greece.

There is little available on the history of drafting as we know it. We do not know just what kinds of drawings the ancients used, but it is likely that some form of combination of plans and pictures was used to indicate the appearance and proportion of the various constructions. It is natural then to suppose that the first draftsmen were artists. It may be interesting to note that Leonardo da Vinci was a drafsman and engineer who made sketches of machines and details of machines. These sketches, according to one of his historians, "are enlivened with a grace and confidence of stroke, an expressiveness of meaning such as no other draftsman ever gave." These sketch books tell us that drafting was practiced as early as 1475. This does not mean the kind of drawing which is used today — but drawings which had the same reasons for being made — namely to give the details of constructions. Projection drawing as we know it is of comparatively modern origin, although drawings have always been more or less used for constructive work.

The science of mechanical drawing is based upon orthographic projection, by means of which objects may be accurately described. The development of this science is due to Gaspard Mongé, a noted French mathematician, who published his work on Descriptive Geometry in 1790. With this knowledge of the theory of drawing, its development became more rapid and its application more general. With simplification and definiteness it was found possible to give instructions to workmen by means of drawings, to record and develop ideas and to describe constructions accurately and completely. It is hard to realize what this has meant in the progress of the world. This possibility of conceiving and building things out of nothing — this possibility of conceiving and describing material things without actually building them. It is not such a long time since models were made for such purposes. In fact, at one time the United States Patent Office required models of inventions. Such models had to be in proportion, had to operate and had to be contained within a box measuring one foot in each direction. Now, models are not allowed and inventions are described by drawings which occupy a space of 8″ x 13″, although more than one sheet is used where necessary. The possibilities of the graphic language are very strongly emphasized when it is realized that the wonderful inventions which have been made in recent years can be represented in such a small space by this mode of expression.

It is interesting to note the effect of drawing in connection with many of the great inventions and the lives of the inventors. It is surprising to learn the number of instances where the most successful in-

ventors, and the greatest engineers have been the men into whose biographies it is written that they were skillful draftsmen. Robert Fulton, the first Americacn engineer of real ability and training had a passion for mechanical drawing. Before he was seventeen years old he was supporting himself as an artist and draftsman. In 1796 his plans were accepted for a cast iron aqueduct which was constructed across the river Dee in Scotland. He had much to do with other engineering matters than the steamboat, and it is said that his undertakings were greatly aided by the many beautiful and accurate drawings which his skill as an artist and draftsman enabled him to make. His fame came through habits of careful experimentation and study developed by his knowledge of the graphic language. His conclusions were preserved in elaborate notes and beautifully drawn plans.

Captain John Ericsson is another famous engineer who was primarily a draftsman. He entered the Swedish army when he was seventeen and was employed in making military maps. His work over the drawing board continued for nearly seventy years. His drawings were remarkably accurate, to the very smallest detail. During the Civil War his designs for new warships were carried on under rush orders. At such times work was started with the first drawing and followed by succeeding drawings which were sent to different plants, so that the work was going on at several places at the same time. Being such an expert draftsman himself, he required the same degree of excellence from those who worked for him, and is said to have been one of the most exacting of employers, for nothing but the very finest, most accurate and painstaking work would satisfy him.

It would be possible to enumerate other connections of the great engineers and inventors with skillful draftsmanship. Draftsmanship means not only mechanical drawing but the graphic language in all forms and as used by the executive and trained engineer — freehand sketching.

James Watt, inventor of the steam engine, first illustrated some of his inventions in sketches included as parts of letters written in connection with his engineering work. Many other engineers have preserved their thoughts by means of sketches. Field, of Maudsly and Field, one of the most famous of early English machine tool builders, had what he called a talking book, or graphic diary, in which sketches and notes were made while talking with prospective customers or in connection with their own machine tool building were carefully preserved.

In the hurry of modern times we seem to have worked away from this old time appreciation of this most valuable science — too often it is thought of as a training of the hand rather than as the education of the eye and brain.

Mechanical Drawing as a Practical Subject

The practical value of mechanical drawing and the ease of using or directly applying even a small knowledge of this subject is so evident that it needs little comment. It is necessary, however, that the larger purposes should be kept in mind.

It is, of course, a fundamental branch of study for industrial and technical training for the workman, engineer, or executive. Its importance as a practical subject is such that drawing must meet modern technical and engineering requirements. Theory alone will not do this. Mechanical drawing is, therefore, a subject with a double value, in that it teaches both theory and practice.

Mechanical Drawing as an Educational Subject

There has been a feeling of uneasiness, of regret, in the minds of many educators over the passing of the so-called classical education. The seeming contempt and somewhat rough shod methods of those who spurn any subject which is not "practical" or which does not have a direct "dollar value" has created a certain unfavorable opinion in the minds of some educators. Drawing has suffered from this. The value of mechanical drawing as applied to the industries is so evident that its cultural value is sometimes neglected. The fact that drawing is useful does not make it any less valuable as a cultural subject. The great value of drawing is not in learning to use the instruments and tools, it is not in learning to read blue prints, it is not in learning how to represent the shape of an object by means of lines, it is not from its value as a trade or profession. Its greatest value comes from a language training, from the mental discipline of a language which requires the ability to imagine definitely, to visualize clearly, and to think accurately. It is what takes place in the brain rather than the lines on a piece of paper or blue print, which gives drawing its greatest value.

SECTION II

A State Survey

The making of a complete state survey of the teaching of any subject would require the services of a number of experts and a large amount of time. The present survey cannot be considered complete but care has been taken, so far as time and facilities permitted, to prevent it from being superficial. The grade schools, high schools and colleges were included, as it was deemed extremely important that the subject be considered as a continuous one.

Questions and letters were used to secure the desired information. While complete answers were not received, enough data was obtained to

indicate present conditions. The grade school and college survey was conducted by the writer. The high school survey was made in collaboration with Professor Thomas E. French of the Ohio State University.

The questions and summarized answers which follow will give some idea of the present status of mechanical drawing in the State of Ohio, the extent of the subject, the time time devoted to it, the kinds of teachers, their viewpoints, and the methods being pursued.

Mechanical Drawing in Grade Schools

The questions which follow were submitted to the superintendents of public schools in 30 of the larger cities of the state and replies obtained from those listed:

Alliance	Marietta
Ashtabula	Massillon
Canton	Newark
Cincinnati	Norwood
Cleveland	Piqua
Columbus	Portsmouth
Dayton	Toledo
Elyria	Warren
Hamilton	Youngstown
Ironton	Zanesville

The replies are summarized for convenience of interpretation.

1. *Is mechanical drawing taught as a separate course in the grade schools of your city?* About 40% of the replies gave "yes" in answer to this question. Three schools reported no mechanical drawing taught in the grades.

2. *In what grades is it taught?* Mechanical drawing is taught in the 7th and 8th grades in over 80% of the schools. Three schools reported 6th, 7th and 8th and one 5th to 12th grades.

3. *About how much time is devoted to mechanical drawing in each grade in hours per week?* The answers to this question showed considerable variation. The most usual time was 1½ hours per week. In many places drawing is given for only part of the school year, from seven to eighteen weeks.

4. *How many pupils take mechanical drawing? Total of all grades? Total number of pupils for same grades for all subjects?* The answers to this question were rather incomplete but indicated about one-half of the pupils in the 7th and 8th grades were receiving some instruction in mechanical drawing.

5. *Is a text book used? Name of text?* About 50% of the schools use a text book. Several reported books available for reference.

6. *How is work presented to pupils?* Lecture or Demonstration — Notes — Blueprints —. Many schools use all four methods. Lectures and demonstrations seem to be favored.

7. *Is mechanical drawing correlated with other subjects?* If so, what subjects? In most schools some attempt is made to correlate drawing and the various shop work or manual training courses and in several schools with mathematics. Only two schools reported no correlation.

8. *Is a definite method of grading drawings used? Explain briefly.* More than half the schools attempt a somewhat definite system of grading but there is no uniformity. Accuracy, neatness, and tech nique form the basis for most grading, with each division about equally favored as first choice. Grasp of subject and time required appear in a number of answers. Many schools have no particular system of grading.

9. *How is the subject of mechanical drawing regarded in your schools?* (Its relative importance, etc., compared with other subjects). While a few answers contained such remarks as "not emphasized", "second place", "not regarded highly", most schools reported mechanical drawing as having an equal standing with academic subjects.

10. *Is mechanical drawing emphasized as a practical subject or as an educational subject?* About 53% reported practical, 37% both, and only 10% educational.

11. *Teachers — Preparation and Experience* — About two-thirds of the teachers have had normal school or similar training, one-fourth have had college training and less than 10% have had no school training for teaching mechanical drawing. Comparatively few teachers have had both school training and practical experience. In most schools mechanical drawing is taught in connection with manual training and by the same teachers.

Mechanical Drawing in High Schools

The answers to the questions which follow were summarized from replies received from 66 high schools where mechanical drawing is taught. This is not a complete list of the high schools in which mechanical drawing is taught but is representative.

List of High Schools:

Central High ..... Barberton	Harrison Twp. High ..... Kirkersville
Central High ..... Bowling Green	Kent Normal High ..... Kent
McKinley High ..... Canton	Lakewood High ..... Lakewood
North Junior High ..... Canton	Lancaster High ..... Lancaster
Hartwell High ..... Cincinnati	Lebanon High ..... Lebanon
Hughes High ..... Cincinnati	Central High ..... Lima
Madisonville High ..... Cincinnati	South High ..... Lima
Woodward High ..... Cincinnati	Lyons High ..... Lyons

City High	Coshocton
East High	Cleveland
East Technical High	Cleveland
Glenville High	Cleveland
Lincoln High	Cleveland
West High	Cleveland
West Technical High	Cleveland
Heights High	Cleveland Heights
Shaw High	East Cleveland
Columbus Trade	Columbus
East High	Columbus
North High	Columbus
South High	Columbus
Parker High	Dayton
Steele High	Dayton
Stivers High	Dayton
Delaware High	Delaware
Eaton High	Eaton
Elyria High	Elyria
Findlay High	Findlay
Fremont High	Fremont
Geneva High	Geneva
Girard High	Girard
Edward Lee McClain High	Greenfield
Hamilton High	Hamilton
Marion High	Marion
Martins Ferry High	Martins Ferry
Massillon High	Massillon
New Dover High	New Dover
Ruggles High	New London
Newark High	Newark
Portsmouth High	Portsmouth
Prospect High	Prospect
Ravenna Twp. High	Ravenna
Salem High	Salem
Shaker Heights High	Shaker Heights
Junior High	Springfield
Springfield High	Springfield
St. Marys High	St. Marys
Scott High	Toledo
Waite High	Toledo
Troy High	Troy
Wapakoneta High	Wapakoneta
Warren High	Warren
Westerville High	Westerville
Weston High	Weston
Westview High	Westview
Willoughby High	Willoughby
Rayen High	Youngstown
South High	Youngstown

1. *Is mechanical drawing taught in your school?* As indicated, affirmative replies were received from 66 high schools.

2. *How many years? . . . Required or elective?*

Answers varied from one-half year to four years, with more than half offering two years. In 25% of the schools it is required, in 75% elective.

3. *How many periods per week? . . . Length of periods?*

Fifty per cent offer five 45 to 60-minute periods per week; 25% offer two 40 to 60-minute periods per week. The remainder vary from the shortest — one 45-minute, — to the longest, — five 120-minute periods per week.

4. *Total number of students enrolled in Mechanical Drawing?*

In the 66 schools listed under question 1, there are nearly 6,000 pupils enrolled in Mechanical Drawing courses.

5. *Is a text book used by the students? . . . Name of text.*

Most of the schools use some form of printed text book. A number of others report that text book and handbooks are available for reference.

6. *Are problems given by blueprints? . . . Printed directions? . . . Blackboard.*

Many schools use all three methods in presenting problem specifications. The blackboard is the commonest method, but a number of in-

structors have made carefully prepared sheets duplicated by blueprinting or mimeographing.

7. *How much work is given from actual objects or models?*

Answers range from "none" to "all." The average amount is 50% of the course, including the drawings made for shopwork.

8. *Indicate briefly the kind of models or objects used.*

Models varied greatly, and included the usual wooden models of type solids, manual training projects, furniture, small castings and machine parts, and complete machines.

Collections of models in different schools vary greatly, in numbers, kinds and usefulness. Many have only the usual wooden type solids, others have joints and manual training projects, including furniture. Still others have castings, sectional machine parts and complete machines. Models once acquired, it would seem, are never discarded, and antique and obsolete forms of machine tool parts and the like are often seen in these collections.

9. *Is the work standard for all your schools?*

This question referred to cities having more than one school, and the replies showed that in very few cities is the work standardized.

10. *Who prepares or outlines the course?*

Usually the teacher. In some cases the manual training supervisor. In one instance, a committee of teachers. In some states syllabi are prepared by the State Superintendent or by the University of the State. These unify the work of the State while allowing individual initiative and freedom.

11. *Are class lectures given?*

Eighty per cent report "yes". These are, however, in the majority of cases, simply class explanations given in the drawing room.

12. *Are examinations given?*

Forty-five per cent report "yes". This important question is discussed later in this bulletin.

13. *To what extent is drawing correlated with shopwork?*

In some schools there is no attempt at correlation. In others drawings are made for everything made in the shops.

There is a general tendency to correlate simple shop projects and drawing.

14. *What difficulties are encountered in correlating shopwork and drawing?*

The majority find no especial difficulties. The principal report of trouble is in the varying sequence of work and that too close correlation has the effect of breaking up the continuity of the drawing course.

15. *What methods are used to keep the class together?*

It is found that generally no attempt is made to hold a class together. Instruction is individual and the pupil works on a drawing until it is finished. In a few schools, however, the entire class starts a prob-

lem at the same time, a time limit is set for its completion, and points are deducted for lateness. This emphasizes the important point often overlooked in school work that in commercial drafting both accuracy and speed are demanded, and that either is worth little without the other.

16. *How do you provide for the slow thinkers?*

The general report is that they are given simpler problems and more individual attention. One report says "we give them time to think."

The increased individual attention should be directed not only toward helping the student over, but toward speeding up what in many cases may be only chronic physical or mental laziness.

17. *How do you provide for the brighter boys?*

In almost every case by extra work and harder problems. The bright boy enjoys the distinction.

18. *What method of grading drawings is used?*

In this there is no uniformity. Some use a letter system, others a numerical system. Some drawings are not graded at all.

19. *Do you use "key" sheets?*

Practically none were reported.

20. *Will you furnish an outline of the drawing courses as given in your schools?*

21. *Will you send an average set of students' drawings in illustration of your course?*

While these two requests were not fully complied with in a number of instances, enough have been seen to indicate a wide divergence, not only in the order and method of presenting the various divisions of the subject, but also in the quality of work required, or accepted, from pupils. Various degrees of completeness in the matter of checking were noted, some drawings having been examined carefully and all points needing attention marked, while some apparently had not been considered as to correctness of detail.

22. *Is the course differentiated or specialized? . . . In what year?*

Special courses are given in comparatively few schools. In some the subject is required as a five-period course for manual training and elective as a two-period course for others. Separate courses in machine drawing, mechanism drawing, sheet metal pattern drawing, and architectural drawing were listed among the answers received. In a number of schools sketches and drawings for a complete machine as a gas engine or speed lathe constituted a course in machine drawing.

23. *What kind of lettering is taught and how much time is devoted to it?*

It is interesting to note the trend of improvement in the styles of lettering used. All schools reporting are using free-hand single-stroke letters.

No summary as to the amount of time spent can be gained from the answers, but the approved method of teaching is to distribute lettering

practice in short assignments through most of the first year, and its applications throughout the course.

24. *Does the student or the school furnish the drawing instruments? . . . Other materials? . . . Text books?*

Drawing instruments are furnished by about 50% of the schools, other materials by about 40% of the schools. In most schools where text books are used, the pupils are required to purchase them.

25. *About what priced instruments are specified? . . . (Cost in normal times.)*

The answers to this question varied in general from $3.00 to $10.00. In one school $20.00 instruments are used.

26. *What does the set include?*

In most cases the set included, compasses, dividers, ruling pen, bow pencil, bow dividers and bow pen.

27. *What kind of paper is used? . . . Size of finished sheet?*

The practice of most schools is to use a good grade of paper of either white or cream. There has been an upward tendency over the practice of a few years ago, in spite of advanced prices.

Sizes of finished sheets ranged from 7″ x 10″ to 21½″ x 29½″, with the greater number seeming to favor a size in the neighborhood of 11″ x 15″.

28. *Are blueprint frames available for students' use?*

In about two-thirds of the schools blueprint frames are used. A few schools reported the use of electric blueprinting machines. One school built a continuous electric machine in its manual training department.

29. *Does the mechanical drawing teacher give whole time to the subject? . . . If not, what other subjects does he teach?*

Thirty-one per cent of the teachers reported as teaching mechanical drawing devote their whole time to the subject. Forty per cent are teaching some form of mannual training or shopwork, and twenty-nine per cent are teaching other branches, including American history, art, chemistry, domestic art, mathematics, physics and science.

It is noticeable that practically all the mechanical drawing in Ohio is now taught by men.

30. *What is the preparation of the drawing teacher?*

(Please answer for each teacher.)

Practically all the teachers in Ohio have a record of some school or college training, ranging from four years of University or technical school to correspondence school or a few weeks of summer school work. Thirty-five per cent have had practical drafting room experience, ranging from one to twenty-five years. Twenty per cent more have had other industrial experience, the remainder have had no experience other than teaching.

31. *What do you consider as the object of mechanical drawing in your school?*

An interesting variety of answers was received on this question. Broadly they may be divided into two groups, one seeing the direct use of the subject, the other seeing it in its larger aspect and truer value. Some typical answers are appended.

"To learn to read a drawing and to become draftsmen."

"To make drawings of simple parts."

"To read blueprints."

"To make draftsmen."

"To get as much college credit as possible."

"To train for accuracy."

"To learn the graphic language."

"I consider it an important part of secondary education. It strengthens the imagination, forms habits of accuracy and careful observations."

"This forms a part of their general education. We don't aim in our schools to turn out tradesmen as yet."

32. *How well is the object attained?*

Curiously, no matter what the object was, practically all agreed that it was well attained.

33. *What is the status of drawing in comparison with other subjects?*

Most reports were that the work was on an equality with other subjects. In the manual training high school drawing is looked upon as an important subject and the department has the same ranking as other departments. In some schools which have no manual training courses, the course in mechanical drawing its not understood nor appreciated by the teachers of other subjects.

34. *What proportion of the students who finish the mechanical drawing course, go to college or higher technical schools?*

35. *Of the proportion who go to such schools what per cent receive college credit?*

The majority of the schools appeared to have no records of the important information necessary to answer these two questions. Those reporting indicated that an average of about one-third of their pupils continued their studies in higher technical schools. All of these are allowed entrance credit, and a few reported that advanced credit was given for high school drawing.

Mechanical Drawing in the Colleges and Universities

The questions which follow were submitted to over 30 colleges and universities in the State of Ohio as listed. This is practically a complete list of institutions of college rank. The first two questions concerned the name of the institution and the head of the department of drawing. Answers to the other questions are here given in general

terms. Discussion of results, together with notes and suggestions, will be found in later sections of this study.

3. *Is mechanical drawing taught in your institution?*

Twenty-five of the thirty schools listed answered "yes." This is 83⅓ per cent.

4. *How many years? . . . Required or elective?*

One year	25 schools
Two years	11 schools
Three years	6 schools

In a few schools drawing is taught four years.

Required in five schools.

Required and elective in five schools.

Elective in fifteen schools.

5. *How many periods per week? . . . Length of period?*

Either two or three periods per week with length of periods of 2 or 3 hours. About 50% of the schools give 6 hours per week, 35% give 4 hours per week, and 15% give 8 hours per week.

6. *Total number of students enrolled in all courses in mechanical or technical drawing.*

The total as reported for 25 colleges is tabulated below for the first half year:

First year	1669
Second year	750
Third year	432
Total	2851

7. *What is the official title of the department?*

Where mechanical drawing is not taught in a separate department, it is handled by various departments as follows:

Art, Applied Mathematics, Physics, Civil Engineering, Mechanical Engineering, Electrical Engineering, Mining Engineering.

Titles given for departments are as follows:

Manual Training Department.

Engineering Drawing.

Mechanical Drawing.

Drawing Department.

Natural Science and Mechanical Drawing.

Department of Mechanical Drawing and Descriptive Geometry.

Department of Engineering.

Industrial Education.

8. *Is all drawing taught by above department? Please explain and give list of courses.*

In some schools drawing after the first year is taught in other departments by the teachers of mechanical engineering, electrical engineering, etc.

9. *How is the subject of mechanical drawing first presented? Please check.*

(a) Use of instruments — line exercise.
(b) Freehand sketching from models.
(c) Freehand orthographic views from pictures.
(d) Freehand orthographic views from copies.
(e) Mechanical drawings from models.
(f) Theory of projection.
(g) Orthographic from pictures.

If a book is used please give name of book and pages which cover first work.

The answers to this question were not all definite but a general idea of the relative preference may be noted by referring to question No. 12.

10. *Is drawing correlated with other subjects?* The answers to this question indicated that there was some attempt at correlation in about one-half of the schools.

11. *What method of grading drawings is used?*

There appears to be little uniformity in methods of grading drawings. In some schools the drawings are not graded until the end of the course. Accuracy, neatness and speed are the considerations in most schools. Definite grades are given in some schools but in others little attention is apparently given to this important matter.

Accuracy and neatness are each given first place in about the same number of schools. Speed is included as the third consideration in most cases.

12. *What subjects are included in your first course in mechanical drawing? Please indicate by numbers.*

Geometrical Drawing.
Lettering.
Freehand Sketching.
Inking Exercises.
Orthographic Projection.

The order in which the various subjects are given in different schools is indicated in the table. Thus eight schools give geometrical constructions first, while only three start with inking exercises. Apparently geometrical constructions are still favorites for the first work in mechanical drawing. Lettering is increasing in importance and inking is being placed later. Curiously orthographic projection predominates in fourth place.

Table showing number of schools which prefer each subject in the order given:

Name of Subject	Order of Preference				
	1	2	3	4	5
Geometrical Drawing	8	4	6	1	1
Lettering	9	6	6	.....	.....
Freehand Sketching	1	.....	1	5	5
Inking Exercises	3	6	8	.....	.....
Orthographic Projection	1	5	.....	10	4

13. *Indicate briefly the scope of your courses in Machine Drawing. Do you use a text book? . . . Name of text . . .*

About one-third the schools listed give a course in machine drawing, using a text book with other books for reference. French's "Engineering Drawing" is the generally accepted text book.

14. *Do you give college credit for Mechanical Drawing done in high schools or other preparatory schools? If so, under what conditions?*

About one-third of the colleges give some college credit for mechanical drawing done in high schools. Presentation of drawings of satisfactory quality or examination is required.

15. *Do you give special courses in mechanical drawing for training teachers of this subject?*

Only three schools answered "yes" to this question.

16. *Are any courses in Mechanical Drawing given in your College of Education? . . . What texts are used?*

Courses in mechanical drawing are offered in the College or Department of Education in six schools. In three of these the courses are the same as for other students.

17. *What size of finished sheet do you use?*

Twenty-six different sizes of drawing paper were specified as listed:

8½ × 11	11 × 15	13 × 19	18 × 28
8½ × 12	11 × 16	14 × 17	19 × 22
9 × 12	12 × 15	14 × 18	19 × 24
9 × 13	12 × 16	14 × 20½	20 × 34
10 × 12	12 × 17	15 × 20	22 × 30
10 × 13	12 × 18	15 × 22	
10 × 14	12 × 19	18 × 24	

18. *How many teachers give their whole time to teaching drawing? How many part time?*

Seventeen teachers give full time and something more than twice that number give part time to teaching mechanical drawing.

19. *Teachers and their preparation.*

About 66% of the teachers are college graduates. About 50% have had practical experience. About 27% have had some college training.

The following table gives some statistics for the schools listed:

	Institution	Location	Is Drawing Taught?	No. of Teachers		Number of Students						Length of Periods — Hours	Sizes of Drawings
						1st Year		2nd Year		3rd Year			
				Whole Time	Part Time	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half		
1	University of Akron	Akron	Yes		1	46	47		28	8	11	3	9 x 12; 12 x 19; 19 x 24
2	Ashland College	Ashland	No										
3	Baldwin-Wallace College	Berea	Yes		1	10	10					2	9 x 12
4	The Bluffton College	Bluffton	Yes		1	11	11					2	10 x 13
5	Capital University	Columbus	Yes		1	8	5	3	3			1	12 x 16
6	Case School of Applied Science	Cleveland	Yes	5		350	325	183	142	80	40	2 and 3	14 x 17; 14 x 18; 18 x 28
7	Cedarville College	Cedarville	No										
8	Defiance College	Defiance	Yes		1	12	7	5	5			2½	10 x 12; 15 x 22
9	Denison University	Granville	Yes	1	1	50	35						9 x 13; 13 x 19; 19 x 24
10	Findlay College	Findlay	No										
11	Heidelberg University	Tiffin	Yes		1	20	20					2	12 x 15
12	Hiram College	Hiram	Yes		1	12	13					1	8½ x 11
13	Kent State Normal College	Kent	Yes		2	11	16					2	9 x 12
14	Kenyon College	Gambier	Yes		1	7	6					2½	11 x15
15	Marietta College	Marietta	Yes		1	20	16					2	12 x 18
16	Miami University	Oxford	Yes		2	29	25	10	8	9	6	3	
17	Mount Union College	Alliance	Yes		1	15	18					3	8½ x 11
18	Muskingum College	New Concord	Yes		1	14	14					2	19 x 22

19	Oberlin College	Oberlin	Yes		1	7	5					3	12 x 18
20	Ohio Mechanics Institute	Cincinnati	Yes	2	6	100	100	50	50	25	25	4; 6; 3	11 x 15; 15 x 20; 20 x 34
21	Ohio State University	Columbus	Yes	8	2	785	530	452	321	210	78		8½ x 11 and multiples
22	Otterbein College	Westerville	Yes		2		4						8½ x 12
23	Ohio University	Athens	Yes	1	1	64	48	7	9				10 x 14; 14 x 18
24	Ohio Wesleyan University	Delaware	Yes		1	16	12	5	4		3		12 x 18
25	Rio Grande College	Rio Grande	No										
26	St. John's University	Toledo	No										
27	Toledo University	Toledo	Yes		2	35	38	22	13		2		9 x 12
28	Wilmington College	Wilmington	Yes		1	5	4				2		12 x 18
29	Wittenberg College	Springfield	Yes		2	26	22	8	8		3		11 x 15
30	College of Wooster	Wooster	Yes		1	16	14	5	2		2		14 x 20½

SECTION III

Content and Character of Courses

A study of the survey as given in Section II cannot fail to impress one with the fact that mechanical drawing is indeed a fundamental subject for study in the State of Ohio. Many variations in the consideration which it receives in the different schools will be noted, together with the fact that it seems to derive its chief value from its utility — its practical applications.

Some discussion of the results of the survey, together with notes and suggestions or comments, are included in this section.

Mechanical Drawing: Essentially mechanical drawing is the practical application of descriptive geometry. More particularly it is the art of visual description by means of lines and figures placed on a sheet of paper in such a way that the shape and size of machines, buildings, etc., are accurately defined.

As taught mechanical drawing may mean any one of a number of things, as: —

(a) The drawing of a few lines on brown paper with pencil and straight edge.

(b) The drawing of geometrical constructions.

(c) The copying of drawings.

(d) Making views of a few simple objects.

(e) A complete course in the theory of drawing including orthographic projection, pictorial drawing, intersections, developments, etc.

(f) The study and making of finished technical drawings of the highest excellence.

In the grade school, mechanical drawing is taught as part of the manual training course and much of the work has to do with the kinds of things which are made in the shops. Such drawing is best taught without presenting the theory of orthographic projection. An explanation of the views by direct comparison with the object and by an examination of simple drawings is probably the most logical and easily practiced method of introducing mechanical drawing.

In the high schools the conception of drawing as a language can be brought out and some of the fundamental laws of projection can be explained. The ability to think in three dimensions and to visualize both shape and size can be developed.

A certain amount of geometrical constructions drawn very accurately and paralleled with the usual draftsman's methods are useful in developing accuracy and an understanding of how to locate lines, arcs, etc., when constructing views. Lettering is a part of all good high school courses in drawing. In some high schools elementary architectural and machine drawing are taught. These studies must not be too

ambitious if the student is to be held responsible for a thorough understanding of every drawing and for every line on every drawing. Such subjects should not be attempted unless the teacher has had real experience in architectural or mechanical work. Mere copying or drawings not thoroughly checked give the student a false idea of the value of drawing.

The development of surfaces and intersections can be taught for simple plane and curved surfaces but general rather than special methods of solution should be used.

Practical problems should be carefully selected for educational value. Such problems are to be encouraged, as they create an interest for the student. It is necessary for the teacher to point out the relation between such drawings and the theory of projection, so that the student may learn to "compose" as well as to "read" and "write" the graphic language.

In the colleges and universities, the first course in mechanical drawing is pretty well standardized, due to the use of Professor French's "Engineering Drawing." Such courses include, Use of Instruments, Geometrical Drawing, Lettering and Orthographic Projection. Sometimes included and sometimes following are intersections, developments, freehand sketching, and pictorial drawing. Descriptive Geometry is generally a separate course and precedes a course in Machine Drawing. Courses in Machine Drawing seem to be less definitely organized and not as generally given as might be desirable.

Freehand Sketchings — Freehand sketching has been defined as the language of the designer and executive engineer. It is the quickest means of making engineering thoughts visible. Sketching is simply mechanical drawing without instruments. Accurate thinking requires the ability to sketch accurately. Accurate sketches lead to accurate thinking. For making engineering notes, sketches are convenient, accurate, and quickly made.

Clean cut single width lines, carefully judged proportions, and exactness in detail are fundamental requirements for good sketches. Freehand sketching practice cannot be given too soon in any course in drawing and should be in constant use as an aid in making and reading mechanical drawings as well as a substitute for them. Every sketch should be sufficiently well done to make it an accurate record, should it have to be referred to at a later date.

Lettering

There is probably no one subject connected with mechanical drawing offering a wider range of possibilities than lettering. The number of people who recognize and appreciate good lettering and its value in both engineering and every day life, is constantly increasing.

The importance of good lettering is generally realized but it is not always given the attention necessary to develop proficiency. In a number of schools short exercises in lettering are given at frequent periods and these exercises are carefully criticized. There are many advantages in such courses. Continual practice over an extended period of time is essential to the acquirement of facility in the art of lettering. If lettering is given as a separate subject and bunched in a short space of time, a good deal of the permanent value is lost, for while intensive practice is necessary, that practice must be sustained if the ability to letter well is to be retained after the instruction ceases. If lettering is given in connection with the regular mechanical drawing work, it should not be given all at one time. Furthermore, a certain amount of lettering should be required on all drawings. It should be remembered that the engineer's figures are a very important part of lettering. Perfectly clear numbers are absolutely essential. Home exercises in lettering can be made valuable but they should receive careful criticism. There are many ways of going about the teaching of lettering, but one of the essentials of all the ways is to provide good examples of the letters, clearly and well made, and with the proportions and peculiarities definitely shown. This requires large examples of the various letters and their component parts, together with examples of spacing and estimating. "Learn by doing" is a favorite motto with many people, and is sometimes adopted for the teaching of lettering. A sample alphabet of small size is placed before the student, and he is told to copy it, and to continue copying until he can imitate the sample. Not knowing the characteristics of the various letters, the student enters upon a long practice and is often discouraged before he overcomes the difficulties and learns from the teacher called "experience".

Dismissing this method, there are a number of excellent systems which may be adopted. First, to start upon the letters of the single stroke commercial Gothic, practicing them in each of the family groups, taking the letters composed of vertical and horizontal lines first, then composing them into words, then take the groups composed of letters with vertical, horizontal, and inclined letters and combine them into words with letters from the preceding group, and finally include the letters composed of curves. Each group should be carefully mastered before proceeding with the following one. This method is well adapted to secondary school work.

Another system is to start with practice in spacing, using the elements of the letters for this purpose, and attaining a facility in the control of the pencil and ability to draw a line at any place and in any direction. The spacing of points, and the joining of them with lines gives valuable practice in preparing to make the letters. Leading from the practice of the elements, these elements may be combined to form letters, in the forming of which the characteristics of each letter can be studied.

Either of the above systems may be worked in two ways, first, starting with large sizes, from 3/8" to 1/2" high and working down to small sizes, or the work may be started directly with the small size (1/8" to 3-16").

Following the commercial Gothic letters, the lower case letters should be taken up in detail in a similar manner. Some teachers start lettering using so-called practice sheets, which the student uses with the knowledge that they will not be collected, or if collected, they will not be graded. He is told to go ahead and practice, without regard particularly, to the final appearance of the sheet.

Another method is to insist upon the most careful work from the first sheet, collecting and grading it as a formal exercise. Any of the methods can be made to give good results but much depends upon the manner in which they are handled by the teacher and upon the teacher's patience.

One of the greatest difficulties which has to be overcome is the tendency of the beginner to hurry the preliminary work in order to get at the real lettering. This often results in the student failing to learn the shapes of the letters, in not getting the proper training in judging spaces with the eye, and in improper stroking of the letters and handling of the pen and pencil. One method of overcoming this is by counting. The teacher can lay out the form of the sheet on the blackboard, and starting with the exercise count a number for each line drawn, requiring all students to draw at the same time. For instance, in drawing perpendicular lines, the teacher would count one, and draw the first line, estimate a space and count again for the second line, resting when a few lines or letters have been made, comparing the results and criticising the students' work, then proceed. In this way the entire class can be kept together, and proper attention can be required for each line.

Lettering may be taught by using the pencil first, until the entire alphabet is completed, or by following each separate exercise and letter with the use of the pen. Large letters should be made in pencil first, very lightly, and then inked. Small letters when made with the pen should be made directly in ink — not penciled and then inked.

Machine Drawing: — The name "machine drawing" is here used because it is the one commonly adopted for advanced courses in mechanical drawing. That it does not accurately describe the purpose and scope of such courses may be admitted.

The writer has said the "machine drawing may be considered as:

(a) A final stage of a course in mechanical drawing.

(b) A course in practical drafting.

(c) A course for the correlation of drawing and engineering.

(d) A transition course between mechanical drawing and machine design.

(e) An introductory or first course in machine design."

The importance of such a course seems to be recognized but as yet there is little uniformity in content or method. Such a course ought to be planned to develop an understanding of the relation of drawing and engineering. Such courses should analyze the structure of working drawings, should apply the idiomatic expressions common to the graphic language, should illustrate the applications and treatment of drawing for ordinary engineering purposes, and should include a thorough study of size specification.

Problems, Exercises and Studies

The value of a course in drawing depends upon the proper selection of problems and the methods of presenting the problems. In this the teacher must be alive to the value of the subject and enthused with the possibilities which it holds. The use of the same problems year after year is sure to take the life and interest from the work, both for the student and the teacher. New problems and new ways of presenting old problems are essential.

The source and selection of problems is a question which is certain to arise. If a book is used, it will supply many problems which can be used as presented, which can be changed, and which will suggest new problems. Other books and references are valuable sources. Problems from the wood and metal shops furnish an almost unlimited supply. Many things which are to be made in the shops can be sketched and drawn. Such subjects are real and create interest. Objects which are more or less familiar are always good subjects, especially at the beginning of the course. Trade papers, engineering and vocational periodicals, and even newspapers often furnish ideas for problems. In this the advertisements should not be overlooked. Commercial blueprints obtained from shops and factories are a still further field from which to draw. The makeup of problems for elementary drawing is often more difficult than for advanced or machine drawing. Each problem should teach something, but several new points should not be included in a single problem. All problems should be "learn something" problems, as distinguished from "keep busy" problems. Large collections of problems on a single sheet should be avoided, as interest wanes before the sheet is completed. All problems should be definite, especially elementary problems. They should all be solved completely and accurately, and by approved methods. Geometrical problems are valuable for teaching accuracy. They should be solved in pencil only, and with extremely delicate lines, and with very definite results. Such geometrical constructions as are generally used should be taught in connection with problems where they occur. A bolt head involves a hexagon, or a cylinder head with six holes gives the same problem — a hexagonal top for a small table, or other applications may be taught of. The copying of a figure — to the same scale, or enlarged, involves the construction of triangles.

Tangent arcs occur on almost all machine parts. An eliptical table top — a gland — a boiler hand hole or a man hole use ellipses.

The use of instruments may be taught by set exercises, or by making drawings of objects which involve the same practices. Orthographic projection should receive especially careful treatment, and should be logically developed. There are several points which should be considered — the problems should be progressive, each a little more involved than the previous one. Problems should include objects requiring two, three, four or more views. The side views should be placed either at the right or left, and opposite either the front or top views. The first problems are to fix the relations of the views, and a number of objects should be drawn for this purpose. Dotted lines and sections should be introduced early in the course. Objects with surfaces parallel to the planes of projection should be taken first, then with faces parallel but at varying distances, then objects having surfaces at angles to one plane, to both planes, etc. All objects should NOT be symmetrical.

In the survey of mechanical drawing previously referred to it is stated that:

"A good problem should:

(1) Illustrate primarily one important feature of the language of drawing, a feature which will recur incidentally on subsequent drawings.

(2) Take its place in the scale of difficulty.

(3) Contain a minimum of repeated detail.

(4) Be an object with whose form, use or place, the ordinary boy would be familiar.

(5) Not be obsolete in design."

These requirements will, in general, apply to almost any course in mechanical drawing, and with some modification to advanced courses.

The manner in which problems are presented should have careful attention to insure development of the points to be taught. Models, pictorial views, incomplete or missing views, and verbal descriptions are some of the methods used. Whatever the method, the requirements should be definitely stated.

At the Ohio State University specification sheets and mimeographed notes are freely used to define problems and to amplify the instruction as given by lectures and text-book study.

Many schools use blue prints, printed notes, mimeographed notes and drawing layouts. At Case School of Applied Science the specifications for the course are prepared by Professor Comstock and mimeographed so that the student has an outline of the work to be done.

At Miami University carefully prepared outlines of the courses are mimeographed. Definite assignments are made so that the student must read the texts in preparation for class work and drawing room work. This method is to be commended, as it insures a thorough understanding

of the subject and informs the student of just what is required. A part of a page of the "Manual" prepared by Prof. Whitcomb of Miami University is shown below.

Principles of Size Description.

A. Changing orthographic and pictorial projections to working drawing.

a. General references for this section.

(1) French, pp. 166-173; 176-177; 315.

(2) French and Svenson, pp. 51-57; 60-63; 184-191.

Class work — 1 hour.

a. Quiz on home readings.

(1) Discuss the subject of perspective drawing under topics developed in the last class period.

(2) Compare the three systems of pictorial representation which you have studied. Which has given you the most difficulty in understanding?

b. Development of the new subject.

(1) Not only shape but size necessary to make a working drawing.

(2) Value of a knowledge of shop practice to a draftsman.

(3) The dimensions which are to be placed on a drawing.

(4) Dimension lines to be drawn first after drawing of object completed. See text fig. 351 (3).

(5) Then find dimensions and put in proper place.

(6) Conventions used . . . lines, figures, arrows, etc.

(7) General rules for dimensioning.

(8) The finish mark.

(9) Limits and fits.

c. Assignment and Explanation of drafting work.

(1) See directions which follow.

D. Assignment of home work — 2 hours.

(1) Study text pp. 166-171.

(2) Give particular attention to the rules for dimensioning (figs. 351-357) should be given careful consideration).

(3) Be prepared to discuss the subject and to reproduce any portion of it on blackboard or paper.

Drafting-room work — 6 hours.

a. Following the rules for dimensioning, dimension fully the projections on sheet No. 6, observing the suggestion given in the last paragraph on p. 166. Also indicate the parts which are to be "finished."

b. Using the entire working space of a sheet (this will be No. 14) copy to appropriate scale, fig. 353. Turn sheet for drawing with longer dimension horizontal and wide margin away from you.

Grade School Mechanical Drawing

Recognition of the fact that a study is no less valuable because it is interesting has made wonderful progress possible in the realm of education. The schoolroom is no longer a place to be feared. Cheerful hearts and happy minds make for keener interest and a better education.

Mechanical drawing is one of the subjects which has a natural interest for the average boy. The enthusiasm which is present at the beginning of this subject can well be capitalized and made use of in furthering the boy's general education — the development of his mind. The initial interest should be maintained by starting to make drawings of real things, however, simple they may be, and explaining the relation of the drawing to the object. The imagination should be stimulated

until the drawing pictures the part in space with its three dimensions. Drawing from models cannot begin too soon. The grade school may seem somewhat early to begin or try to begin to teach a boy to think in three dimensions. However the place to begin any subject is at the beginning and drawing is no exception to this rule.

The vision of a bottle of ink and a ruling pen should not be held up as the things which make a draftsman. In fact, the use of ink in grade school work is of doubtful value. Considerable proficiency in penciling should be attained before using ink at whatever age the subject is taught. Too often the pen and ink are used as a cure-all for the inaccuracies of pencil work.

The purpose of a course in mechanical drawing in the grade schools is the same as for all other courses. This purpose is to educate; to train the mind and hand, to develop the individual so that he may enjoy life, respect labor either mental or manual, and value citizenship and good government. The immediate purpose of a mechanical drawing course is to train the pupil in the greatest of all languages, the graphic language. To be sure the practical value should not be underrated but it should not dominate. Whether a boy is to be a draftsman, a cabinet maker or a machinist should not be a factor to decide whether he is to study mechanical drawing any more than the expectation of living in France or Spain should be the reason for studying those languages. The study of geography should not be limited to those who expect to travel the world over nor the study of English to those who expect to be preachers, and writers and speakers, etc. Drawing in the grades, manual arts in the grades, notwithstanding their practical appeal, should be put upon the same plane as other subjects and taught to all students. There is no reason why mechanical drawing should not be studied by girls as well as boys. In fact, girls very often surpass boys in lettering and in theoretical drawing. With this in mind teachers should ever have the educational value of drawing before them when planning courses for grade schols.

Without going into detail, the contents of a mechanical drawing course for grade schools should include, the use of instruments by applying them to making drawings of simple objects, training in the use of the scale so that accurate measurements can be made, simple lettering with plain figures, and the elements of three-view drawing without a study of the theory of projection. Neat and carefully made drawings with an appreciation of the value of exactness in scale, representation and specification should be the aim of grade school courses.

High School Mechanical Drawing

Mechanical drawing has come to be recognized as a fundamental subject in the high schools where it is taught. In the technical high

schools it is one of the important courses of instruction. As a practical course its place is fully established. There is, however, much to be desired in the way of a fuller understanding of the true value of mechanical drawing by those who teach it as well as by teachers of cultural subjects. "Mechanical drawing, when properly taught, is pre-eminent in developing the constructive imagination, the ability to think in three dimensions, and to visualize clearly and accurately, an ability which every citizen should have, but which unfortunately is possessed by a very few."

The teacher should have the cultural value as well as the practical value of mechanical drawing in mind when arranging the content of a course. "The use of instruments is simply a means to an end, they are used for writing in the graphic language, as the pencil or pen are used in writing English, or French. A good 'hand' should be developed, starting with the 'alphabet of lines' and carried through 'reading' and 'writing' graphically. The power of visualization should be developed soon after the power of description has been developed. Drawing as a means of developing ideas is unsurpassed, but it must be taught in a logical manner. Each part of the course must bear a definite relation to the other parts. Drawing is an exact mode of expression and requires exactness of representation and exactness in thought."

"In considering the language of drawing, the two important things in the description of an object are its shape and its size. The natural grouping of the elements leads to arrangement in grand divisions or parts.

A. — A study of the instruments, materials, etc., and their uses.

It should be emphasized that this is preliminary to the study of the subject. Good form should be taught at the beginning and constantly insisted upon. Problems for this purpose should be selected to bring out the possibilities and limitations of the various instruments, tools and materials. There are many drawings which can be made with the scale, the T-quare and the triangles. The proper use of the scale, the number of operations involved, the position and handling of the T-square and triangles are questions of good form and are teaching points having direct educational value. Lettering should be introduced early in the course, with careful criticism of the forms of the letters and their combinations into words.

B. — A study of the elements of shape definition.

This is the definition requiring the most careful thought. The shape is of course described by projections and here orthographic projection must be treated adequately, first as different views, without reference to the planes of projection, but followed very soon by the demonstration of the third angle. The ability to think in three dimensions, to get a clear conception of surfaces variously arranged with respect to one another and their position in space, presents difficulties for

the pupil not always realized by the teacher. The apparent simplicity of orthographic projection when applied to a single rectangular block is deceptive. For this reason a nice balance of theoretical and practical subjects is necessary in order to secure the proper training, although the pupils need not know that he is studying theory, and indeed, the words orthographic projection need not be used in class at all.

As to problems for shape study, the progression should be — drawing from models, from pictorial views, supplying missing views or other views and from verbal description. Type solids can be used to a limited extent, but real things should predominate. Much of the study of shapes may be done by freehand sketches in order to save time.

The change from the usual two dimensional thinking to space conception is more radical than generally assumed and particular efforts must be exerted to use subjects which will enable the pupil to get away from thinking in "the flat."

A study of shape definition includes the representation and visualizing of the elementary solids and their various combinations in natural and in out-of-the-ordinary positions; the representing and visualizing of invisible parts and a clear understanding of the meaning of such representation; the representation of the interior of objects and combinations of objects by use of conventional cutting planes.

The number and choice of views, as well as their arrangement, should be studied and analyzed. Problems should be selected which will cover these points and in such a way that there will be an easy transition from one to the other until the subject as a whole is worked out.

C. — A study of the elements of size definition.

There is a certain lack of definiteness in the subject of dimensioning which causes it to be neglected as a grand division of mechanical drawing. It is generally treated by giving a list of rules without a complete exposition of the rules and their application. This subject should be classified as completely as orthographic projection and problems in dimensioning should be given to illustrate the elements. From the sizing of simple objects the problems should lead to combinations, with an orderly procedure of work. The systems of dimensioning should be taken up and advantages and disadvantages discussed. Dimensioning should be applied to wood, castings, forgings, and sheet metal. At the same time the machines used in the industries should be described, and the operations which are performed on them with the materials used for different purposes, should be explained. This is just as necessary for the making of intelligent drawings as for shop courses.

D. — A study of the application of the preceding divisions to practical drafting.

This involves the presentation of the various kinds of working drawings, detail and assembly drawings and their relation to each other.

The source and path of a set of drawings should be followed out. The conventional practices of the drafting room should be explained and their uses studied and applied. The reasons for the existence of such conventions is a part of this study.

Intersections, developments, cams, gears and similar position and area problems can be taught and understood best after the elements of space and size description have been thoroughly mastered.

An added interest and value in sheet metal pattern drafting can be had by building paper models from the patterns as worked out in intersection and development problems.

In preparing a course in mechanical drawing the teacher should bear in mind that he is beginning a subject of unlimited scope and should seek an outline having as logical and definite a sequence of divisions as any other subject. The initial enthusiasm of the pupil should be utilized and a feeling of respect for, and appreciation of, the wonderful possibilities of the graphic language should be developed as early as possible."

Technical School Mechanical Drawing

In the technical schools, colleges and universities of the State mechanical drawing is taught with a definite aim — its use in the study of engineering in school and the later use of engineering knowledge through life. In the technical schools, drawing is most nearly appreciated at its full value. Courses are carefully planned and the student's acquisition of skill and knowledge is carefully supervised. As the language of engineering its importance is realized. The theory of drawing is thoroughly taught and training in exact thinking is given by courses in Descriptive Geometry. Special courses to facilitate the use of drawing, present the conventions and idioms of the graphic language which have developed in the various industries and branches of engineering and architecture.

The position of mechanical drawing in some schools is weakened very much by teaching it as an adjunct to another department. By whatever name, the department of graphics or engineering drawing should be a separate department. In some schools drawing is handled by teachers whose major interest is in other subjects. In other schools there is a feeling that each of the degree departments, mechanical, electrical, etc., should teach drawing to its own students. A full appreciation of the subject should accord it the standing to which it is entitled.

The department of graphics should include mechanism, machine design and graphical analysis in order to be complete. Its staff should be competent to handle the advanced work and so be in a position to give a thorough grounding in the basic courses in mechanical drawing, descriptive geometry and machine drawing.

SECTION IV

Teaching Mechanical Drawing

The successful teaching of any branch of knowledge requires two major interests. First, an interest in the welfare of others, and second, an interest in the subject being taught. For these there are no substitutes. In addition to these interests the teacher should have a sense of value so as to properly emphasize the important divisions or parts of his course. He must be well grounded in his subject and understand its relation to other branches of knowledge and its relation to life.

The Teacher's Qualifications

There have probably been more ways of teaching mechanical drawing than almost any other subject. Not so very long ago almost anyone who had handled a few drawing instruments qualified as a teacher of drawing and the subject suffered from amateur handling. There may be differences of opinion as to the methods of teaching this subject and rightly so, for the best method will depend upon the personality of the teacher.

Present day teachers are coming to appreciate the magnitude and usefulness of drawing and, what is more vital, is that they realize the responsibility which is theirs in giving the first impressions of drawing to those who will make use of it.

The qualifications of a drawing teacher, as stated in the High School Survey previously referred to, may well be quoted as applying to all teachers of this subject. "The success or failure of any course is in a large degree dependent upon the teacher. In any subject the finest results come with a teacher thoroughly imbued with the spirit of his work and who has the qualities which enable him to arouse and maintain interest and enthusiasm. In addition to these qualities, "the teaching instinct," the ideal drawing teacher must have as essential qualifications, a thorough grounding in both the theory and teaching methods of his subject, and experience in the practical use of it. This combination is comparatively scarce and such a man cannot be had for the usual salary paid to ordinary teachers of classical subjects.

Pedagogically, this subject of graphics is one of the most difficult of all subjects to handle, on account of the varying powers of constructive imagination among students of equal mental ability.

Two general classes of men are found as instructors in drawing, first, the practical man taken from the shops, second, the man from college, technical school or teachers' college. The practical man may not have, and often does not have, any teaching ability, and the college man may not have had any practical experience in the actual use of his

subject. The man with school training only should be required to get out into commercial drafting work in the summer, and the shop trained man to go to a summer school to learn methods of presentation and the pedagogy of his subject."

The teacher of mechanical drawing must have infinite patience in presenting and explaining his subject to the class and to the individual. He must be able to analyze the difficulties which confront the student. He must be able to tell when a student really understands a principle or its application. He must be skillful in handling the draftsman's tools. He must understand the relation of his subject to other studies and to its use in the industries. He must know the educational possibilities of the graphic language. He should have a well rounded, general education and an appreciation of the value of other courses of study in the curriculum.

The Status of Mechanical Drawing

What is best in education for the people of a country or of an age, cannot be settled for all time. The needs change and with them, the means of education, subjects studied and methods of study. Tradition plays an important part in education. Educators often are possessed with the fear of appearing radical, and in this open themselves to comparison with the Chinese ancestor worship. There is no dispute with those who hold the study of language and literature to be the main element in instruction. The important place which it occupies is secure. At various times there have been those who have exalted some particular department of knowledge and decried others. Mathematics and scientific studies have not yet been accorded an equal rank educationally with literary and purely cultural subjects. The relative worth of different subjects of study cannot, should not be settled upon an arbitrary standard, yet there are people who hold opinions that this study or that study is not educational and is unworthy of ones' time and energy.

True education must supply man's present needs. These needs are not alone physical but mental, esthetic, and religious. There are higher needs and lower needs. Training of the mind alone or of the hands alone is not education. We need some studies which do one, some which do the other and some which do both. This last important class is where mechanical drawing belongs. It is one of the comparatively few subjects which develops the ability to think, the ability to see, the ability to imagine and the ability to do.

This, then, is the status which mechanical drawing should occupy. Unfortunately, it has not reached this position as yet. A true appreciation, a thorough knowledge and understanding and a real respect upon the part of the teacher will do much to place the subject where it belongs.

Correlation with Other Subjects

Illustration and graphic analysis are so widely applicable to the study of almost any department of knowledge that the possibilities of correlation of drawing and other subjects are numerous. While drawing is the language of engineering and has a great value in this one use, it must not be thought of as less important educationally than the acquisitions of knowledge or the accomplishments which it makes possible.

The most usual correlation is that of drawing and shopwork. In the grade schools there is danger of making the drawing subordinate to shopwork. The drawing then loses mosts of its educational value. A real understanding of drawing cannot be taught where the course consists of making drawings of things to be made in the shop without additional instruction and the application of principles to other objects. The objects drawn must be such as will teach fundamentals, maintain interest, and develop the imagination. Drawings made for or in the shop should be required to attain the same standards of neatness, accuracy and completeness as those made in the drawing classes. There should be correlation of effort by the shop and drawing teachers.

Other studies which readily lend themselves to correlation with drawing are art, physics, and the natural sciences, mathematics, and English. The use of sketches and drawings as a part of other courses greatly increase the interest of the student and helps him to obtain a better understanding of all his studies. The English used on drawings in the form of notes and specifications, descriptions of graphical methods, composition of titles, meanings of words and names of parts and processes — all of these should receive consideration from the English Department.

Geometrical constructions, graphical solutions, curve, plotting, etc., should be analyzed, and studied on both the mathematical and graphical basis.

Not only interest but a quicker understanding and a keener intellect are served by the correlation of subjects. Drawing should be thought of in very much the same light as English, important in itself but necessary for the study and understanding of all other branches of knowledge.

Inter-relation of Grade Schools, High Schools and Colleges

The inter-relation of the grade schools, high schools, and colleges should be recognized. In each division of the educational system there should be a rather definite policy as to purpose, content and presentation, for the subject of mechanical drawing. The grade school teacher should have a good knowledge of the work which is to follow in the high school. He can then shape his course so that it will serve as an introduction to the succeeding courses. This can be done without sacrificing his own

needs of mechanical drawing for use in connection with shopwork or as an educational study.

The high school teacher should inform himself of what is being done in the grade schools and in the technical schools and colleges. He should seek to ascertain their needs and the reasons which underlie the choice of subjects. He should try to formulate the relation of his course to the others and adjust it where possible.

The college teacher should learn the viewpoint of the high school teacher and should co-operate with him. There should be recognition of good work done in the high school. The college teacher should not expect too much from the boy who has had drawing in the high school, but he should not place too low a value upon what has been well done. High school teachers are very willing to co-operate if they can understand where they can work to advantage. It should be possible to tell the high school teacher definitely what their boys may expect upon entering college. However, as stated in the bulletin by French and Svensen, college credit or preparation for college, should not be the primary object of the high school course. "The work should be self-contained and planned rather for the 75 to 90% of boys who do not go to college, than for the smaller percentage who have that opportunity. This course, well and logically arranged with an appreciation of the real value of the subject, will be the best preparation for the prospective college student. * * * A high standard of execution and accuracy should be insisted upon in the high school, good form in the handling of the tools and an understanding of the common geometrical constructions, together with their use in applied drawing should be taught. Lettering is another weak point with the average boy. The difficulties of teaching this subject are not to be underestimated, but a certain degree of proficiency can be attained.

These points are, as before stated, just as necessary and valuable for the boy going into the industries as for those who go to college. Rather than attempt to cover too much, it is better to teach the elements thoroughly."

The Use of Text-books, Notes and Blue Prints

There has at times been a disposition upon the part of some teachers of drawing to look upon the use of a text-book as a reflection upon their knowledge of the subject and their ability to teach it. Just why this is so is hard to understand. No one thinks less of the mathematics teacher for using a text-book. He could undoubtedly teach without one, but the number of students efficiently handled would be very small. What is true of mathematics and other subjects is just as true of drawing. Text-books should be used as an aid, not as a substitute for teacher. As stated in the High School Report:

"With the conception that drawing is a real language, a subject with

cultural value, to be studied and taught in the same way as other subjects, there seems to be little argument as to the desirability of using a suitable text-book with the class. No one probably would advocate teaching algebra or Latin by giving out notes, yet in many instances drawing is taught using only a set of blue-printed problems, with no text or reference books. However well the teacher may be able to present his problems and bring out the teaching points by lecture and individual instruction, the fact remains that the pupil cannot absorb and retain them all. Much valuable time used in repeating instructions can be saved by the assignment of study and reference work from the text-book. The pupil who has been absent is not left hopelessly behind if a text-book assignment covering the work missed is given him. The teacher's efficiency is greatly increased.

A text-book should be more than a collection of problems. It should present the subject matter in a clear, orderly and logical arrangement of the divisions, explaining why each rule or custom is made, and illustrating with examples representing good modern practice."

The selection of a text-book is an important matter and should receive the attention which it deserves. A book should be examined with the idea of finding out what it can be used for. Is it easy to read and understand? Is there too much or too little detail? Does it start at the beginning and take up the subject so that its use can be seen, is it dry and theoretical, or is it merely a statement of facts? Is it exact without being too lengthy or is it too brief for the average student? Does it contain what is essential for an average course or does it cover too many subjects? Does it include too much matter that is little used? Is it "scattering" or "to the point"? Is it a help to the teacher or does it attempt to take the teacher's place? Does it allow the student to think or is all the thinking done? Does it teach real present-day practice? Does it contain problems which are conveniently arranged for use? Do the problems fit the text? Does it contain the "why" as well as the "how" of the subject? Is it a book for the student to keep after he finishes the course?

For the grade school the book should not try to teach too many things. Probably one of the best is Bennett's "Grammar Grade Problems in Mechanical Drawing."

For the high school there are a number of books available. It is well for the teacher to own several of them. Different treatments can be illustrated by Anthony's "Mechanical Drawing", Babbitt's "Working Drawings", and French and Svensen's "Mechanical Drawing for High Schools".

A comprehensive treatment of Engineering Drawing is French's "A Manual of Engineering Drawing", which includes mechanical drawing, working drawings and sketches, structural, architectural and topographical drawing. Other books are listed under a later heading.

Notes and blueprints form an important part of the instruction in many drawing courses. No book, however complete, can be perfectly suited to all requirements. For this reason additional notes and references, co-ordinated with the text-book serve to extend its usefulness.

Actual shop blueprints carefully selected to illustrate the principles set forth in the text, help to maintain interest and increase the range of problems.

Recitations and Examinations

Mechanical drawing is primarily a laboratory subject so far as the making of drawings is concerned. As such it brings the teacher into intimate contact with the student, providing that classes are kept small. With large classes, recitations and examinations in mechanical drawing are extremely desirable. Home work based upon an assigned lesson in the text should be followed by recitations and blackboard work.

Pupils in the grades, and often college students, can make drawngs when aided by models and partial views, for rather complex devices, but are unable to read the same type of drawing unaided. Pictorial sketches, either perspective or isometric, serve as a very useful means of testing the student's power of visualization. The student's descriptive power is increased when he has to describe methods and principles in words as well as by making drawings.

Tests and final examinations in mechanical drawing are just as necessary as for other subjects. Tests serve to bring out the points which are not understood, to indicate the degree of confidence possessed by the student, and show his speed in thinking and working. The necessity of reviewing furnishes a means of clearing up many doubtful ideas. The writer believes that short tests should be given very frequently rather than one or two long examinations.

Examination questions should be designed to bring out the desired information with the least amount of drawing. They should be very definite as to the requirements. They should not be involved or "catchy". They should be designed so that the solution and answer can be easily seen and checked. Problems can often be stated so that the answers can be sketched freehand. When duplicating machines are available, the problems can be stated and partial views given, together with other information to facilitate the student's work and save time..

Grading Mechanical Drawings

Every drawing made by a student should be carefully checked and graded. This should be done and the work returned to the student for necessary alterations and corrections as soon after its completion as possible. The full value of the instruction cannot be received by the student if his work is allowed to become "cold" by keeping it for a long period before returning it to him. The student should have the benefit of the

criticisms to aid in the succeeding sheets. A definite grade should be given the work and the student should be informed of the basis for that grade. An appreciation of the value of a certain amount of speed should be taught by setting a time limit for all sheets and deducting from the grade for work handed in late.

The general items for consideration in grading a drawing are:
Correctness
Accuracy
Quality of line work
Lettering, title, etc.
Dimensioning.

The valuation to be placed on each division is subject to variation with the nature of the assignment. Each division may often be further subdivided to advantage, especially when grading the first few sheets.

Another set of considerations for somewhat advanced work is:
Method of Solution
Correctness of work
Character of mistakes
Dimensioning, etc.
Quality of work.

Some schools use credit slips which are attached to the student's work when returned to him. This method is to be commended, as it tends to insure careful attention to grading by the teacher and informs the student just where his work is defective.

A form of credit slip used in the high schools at Sioux Falls, S. D., by Mr. P. D. Gawne is shown in Fig. 1.

Sheet No.	
Balance	
Lettering	
Figures	
Solution	
Inking	
Lines	
Title	
Neatness	
Dimension Lines	
Shade Lines	
Construction Lines	
Center Lines	
Dotted Lines	
Full Lines	
Arrow Heads	
Grade	

FIG. 1

At Miami University Professor Whitcomb uses a printed form with the items shown in Fig. 2.

Name .....Date Due.....

Course .....No.....

Group No.....Division.....Plate.....

	Maximum Credit	Sketching	Penciling	Inking	Tracing	Blue Printing
Correctness	.40					
Clearness	.20					
Accuracy	.15					
Neatness	.10					
Lettering	.10					
Speed	.05					
Average	1.00					

Fig. 2

A record of grades should be kept in such a form that the student's standing can be observed at any time. Graphical methods lend themselves to this purpose, as illustrated by Figs. 3 and 4, which show the forms of record cards used at the Ohio State University. Fig. 3 is for elementary work and Fig. 4 for advanced work.

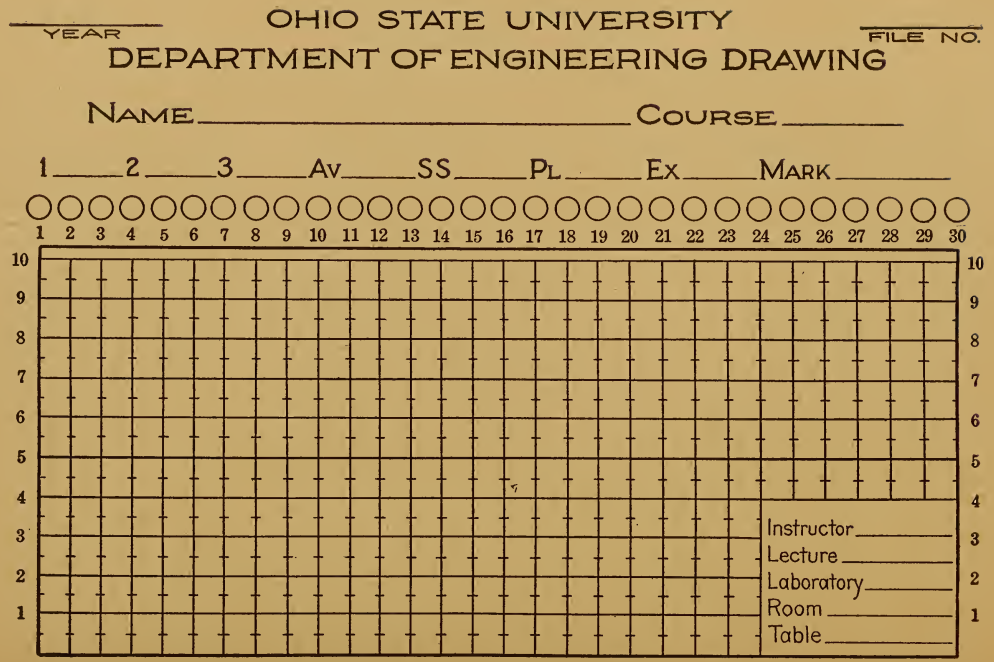
YEAR
OHIO STATE UNIVERSITY
FILE NO.
DEPARTMENT OF ENGINEERING DRAWING
NAME
COURSE
1
2
3
Av
SS
Pl
Ex
MARK
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
10 9 8 7 6 5 4 3 2 1
Instructor
Lecture
Laboratory
Room
Table

FIG. 3

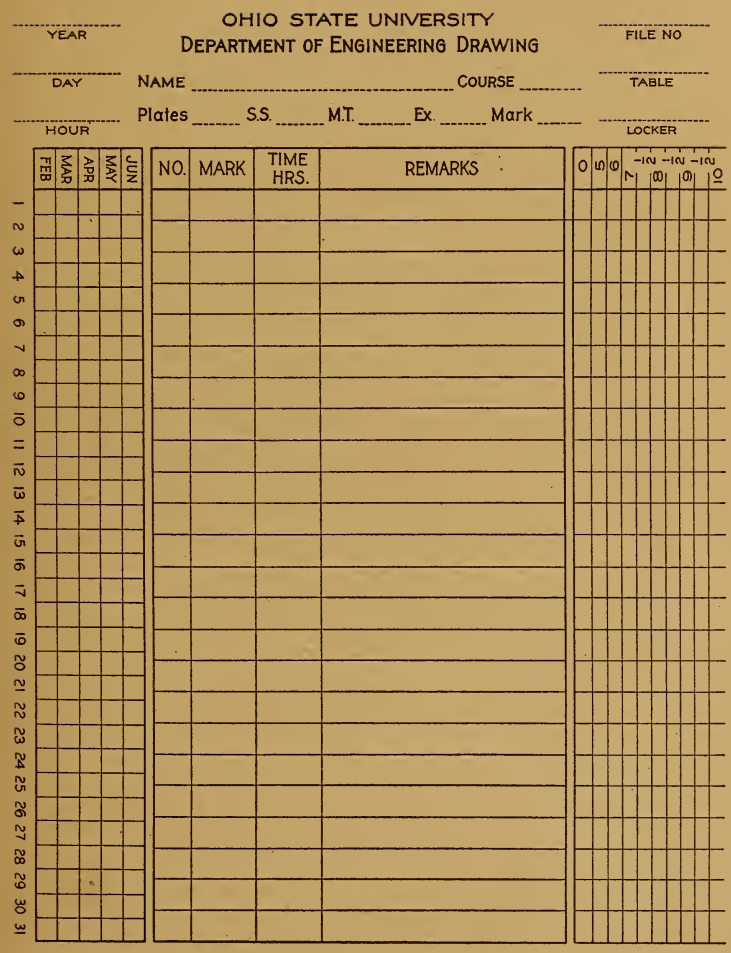
YEAR
OHIO STATE UNIVERSITY
DEPARTMENT OF ENGINEERING DRAWING
FILE NO
DAY
NAME
COURSE
TABLE
HOUR
Plates
S.S.
M.T.
Ex.
Mark
LOCKER
FEB
MAR
APR
MAY
JUN
NO.
MARK
TIME HRS.
REMARKS
0
5
6
7
8
9
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

FIG. 4

A Bibliography

Every teacher of drawing should own and read other books than the one used as a text. He should become familiar with new books and should understand their value for reference purposes for himself and his students.

A complete list of books having to do with mechanical drawing would be very long; over one hundred have been listed by members of the writer's class for mechanical drawing teachers. Many books, however, are written for special conditions, others are out-of-date and some should not have been written at all.

Books for reference, study and extra reading may be selected from the following list:

"Cam Design and Manufacture"
F. B. Jacobs. Pub. by D. Van Nostrand, N. Y.
"Cams, Elementary and Advanced"
F. R. De Furman. Pub. by Wiley & Sons, N. Y.
Drafting Room Methods, Standards and Forms
Chas. D. Collins. Pub. by D. Van Nostrand, N. Y.
Elementary Mechanical Drawing
John E. Jagger. Pub. by C. Griffith & Co., London, Eng.
Elementary Mechanism
James and MacKenzie. Pub. by Wiley & Sons, N. Y.
Engineering Drawing
Thomas E. French. Pub. by McGraw-Hill, N. Y.
Essentials of Gearing
Gardner C. Anthony. Pub. by D. C. Heath, Boston
Essentials of Drafting
Carl L. Svensen. Publ. by D. Van Nostrand, N. Y.
Essentials of Lettering
French and Meiklejohn. Pub. by McGraw-Hill, N. Y.
Lessons in Lettering — Two Books
French and Turnbull. Pub. by McGraw-Hill, N. Y.
Freehand Lettering
F. T. Daniels. Pub. by D. C. Heath, Boston
Freehand Sketching
F. E. Mathewson. Pub. by Taylor-Holden Co.
Springfield, Mass.
Fundamentals of Mechanical Drawing
R. S. Kirby. Pub. by Wiley & Sons, N. Y.
Grammer Grade Problems in Mechanical Drawing
C. A. Bennett. Pub. by Manual Arts Press, Peoria, Ill.
Introduction to the Graphic Language.
G. C. Anthony. Pub. by D. C. Heath, Boston.
Lettering for Draftsmen
Charles W. Reinhardt. Pub. by D. Van Nostrand, N. Y.
Machine Design
Henry Spooner. Pub. by Longmans, Green & Co., N. Y. A good English book.
Machine Drawing
G. C. Anthony. Pub. by D. C. Heath, Boston

Machine Drawing
Carl L. Svensen. Pub. by D. Van Nostrand, N. Y.
Machine Drawing and Design
Lowe and Bevis. Pub. by Longmans, Green & Co., N. Y.
This is a standard English book.
Mechanical Drawing
G. C. Anthony. Pub. by D. C. Heath, Boston.
Mechanical Drawing for Secondary Schools
Crawshaw & Phillips. Pub. by Scott, Foresman Co., Chicago, Ill.
Mechanical Drawing for High Schools
French and Svensen. Pub. by McGraw-Hill, N. Y.
Mechanical Drawing
Pub. by Industrial Press, N. Y.
Mechanical Drawing
C. C. Leeds. Pub. by D. Van Nostrand, N. Y.
Mechanical Drawing
C. W. Weick. Pub. by McGraw-Hill, N. Y.
Mechanical Engineer's Pocket Book
Wm. Kent. Pub. by Wiley & Sons, N. Y.
Mechanical Engineer's Handbook
L. S. Marks. Pub. by McGraw-Hill, N. Y.
Shop Sketching
Ralph Windoes. Pub. by Bruce Publishing Co., Milwaukee, Wis.
Working Drawings
A. B. Babbitt. Pub. by Henry Holt & Co., N. Y.
Working Drawings of Machinery
James and MacKenzie. Pub. by Wiley & Sons, N. Y.

Courses in Mechanical Drawing

There are so many factors affecting the makeup of a drawing course that it is necessary to be somewhat general in regard to the details. The planning of a course is a matter of greatest importance and should not be left to chance or worked out from day to day. A well planned course is necessary to produce satisfactory results. In a city or town the general outline should be worked out by all the teachers together. The details may vary, but the extent of the subject covered and the results to be attained should be the same for all classes of a given grade. Moreover, the course should be planned as a part of a continuous subject extending from the 7th grade through the high school. It is neither necessary nor desirable for the high school teachers to plan the work for the grade schools. All the teachers of the subject should meet upon a basis of equality and together plan the content and relation of the several separate courses.

The importance of the first course should be recognized and preferably taught by the best man available, who should be paid accordingly. The fundamentals must be taught as thoroughly as possible. Drawing should be taught as a language from the very beginning as a means of expression and never as a kind of picture making.

There are many factors involved, such as the community in which

the school is located — the percentage who go to college — the percentage who go into shops and offices — the age at which the subject is started, the amount of time which can be given to the subject, etc., — a warning which should be emphasized is "Do not try to teach too many different things in a single course." It is better to teach a few principles thoroughly than to scatter the student's efforts. All work should be well done and the teacher should insist upon a real understanding of a sheet completed before allowing the next one to be started. It is not a question of how many drawings or how large and complex but of how well done and how well understood.

In the colleges, mechanical drawing courses are generally planned on similar outlines and follow French's "Engineering Drawing". Engineering students should be taught the value of accuracy and neatness in solution, and thought. To this end correct work should be required of every student.

Each part of every course in mechanical drawing should be analyzed with the following considerations in mind:

Purpose
Methods of Presentation
Methods of Solution
Results.

There is one attitude which is taken by some teachers which has been expressed all too frequently in the remark, "I want to get just enough to teach the subject; I don't need to know all about it, as I don't want it to use." Such an attitude certainly is not one of the desirable qualifications of a drawing tacher. Both training and experience are necessary.

Special teacher training courses should be given where the subject of mechanical drawing can be discussed as an educational subject and as a useful art in the industries. Some of the considerations are:

The purpose of the course
The makeup of the course
Relation of subject matter to age and environment of students
The selection of problems
The presentation of problems
Checking methods of solution
Recitations and examinations
Grading and recording
Selection of materials, instruments, etc.
Uses of mechanical drawings
Duplicating machines and methods
The literature of the subject.

A noted in the results of the survey, there are few colleges which offer specially designed courses for teachers of mechanical drawing. Ohio State University and Miami University and the normal schools pro-

vide such courses. There should, however, be a more general realization upon the part of drawing teachers of the necessity for such special preparation.

SECTION V

Conclusion

The preceding sections have indicated the writer's attitude toward the subject of mechanical drawing, so that no extended conclusion is considered necessary.

A few points may, however, be emphasized and one or two additional suggestions made as follows:

An adequate understanding of the purpose of courses in mechanical drawing in grade schools, high schools and colleges.

An agreement as to the general content of each course.

An agreement as to the quality of work expected in each course.

A somewhat uniform standard or system of grading drawings.

A recognition of the inter-relation of grade schools, high schools and colleges.

A consideration of mechanical drawing as a continuous course through the grade schools, high schools and colleges.

A desirable feature would be the issue of a syllabus for courses in mechanical drawing and other subjects by the State Department of Public Instruction.

Definite state requirements for each course would seem to be desirable. The actual problems, etc., can well be left to the teacher, but the general subject matter might well be systematized for the various courses.

Recognition of, and provision for adequate preparation of teachers of mechanical drawing. There should be certain required qualifications for teachers of this subject.

This survey indicates that the subject of mechanical drawing is very generally taught throughout the State but there seems to be rather less definite agreement as to purpose, content and methods than for other fundamental studies.